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Biological Stock Update (for 1984) for American Plaice in NAFO Division 4T

by

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ABSTRACT

An analysis of commercial landings at age with and without discard estimates was conducted. Landings for 1984 were slightly higher than for the previous four years. Research surveys indicate population levels to be similar to levels of the early 1970's. Commercial catch rates calculated from seines, tonnage class 2, (GRT) remained constant from 1977-1983, and decreased in 1984. Abundance indices from research vessel surveys indicate that this stock, despite an observed increase in discards, is able to support a TAC of 10,000 t.

RESUME

Des débarquements commerciaux ont été analysés par âge avec ou sans estimation du nombre de rejets. Les débarquements de 1984 étaient légèrement supérieurs à ceux des quatre années précédentes. Des enquêtes ont indiqué que les populations étaient semblables à celles du début des années 70. Les taux de prises commerciales calculés pour la pêche à la senne en bateau de classe de tonnage 2 (tonnage brut enregistré) n'ont pas varié de 1977 à 1983 et ont diminué en 1984. Les indices d'abondance d'après les relevés de bateaux de recherche indiquent que ce stock, en dépit d'une augmentation observée des rejets à la mer, peut tolérer un TPA de 10 000 t.

INTRODUCTION

The most abundant flatfish in the southern Gulf of St. Lawrence, NAFO Division 4T is American plaice, Hippoglossoides platessoides, (Table 1). Other commercial flatfish species include yellowtail flounder, Limanda ferruginea; witch flounder, Glyptocephalus cynoglossus, winter flounder, Pseudopleuronectes americanus; Greenland halibut, Reinhardtius hippoglossoides; and Atlantic halibut, Hippoglossus hippoglossus.

Flatfish landings in NAFO Divisions 4RST since 1963 have averaged 20,000 t annually, (Fig. 1). Average annual landings from 1975-1980 were approximately 25,000 t. In more recent years (1981-1984) average landings declined to 15,000 t. In 1984, a total of 15,441 t was landed.

The flatfish fisheries, with the exception of the 4RS witch flounder fishery and the inshore 4T winter flounder fishery, are mainly by-catch fisheries to the southern Gulf of St. Lawrence cod fishery. Only 4T plaice and 4RS witch flounder are subject to quota management.

This paper presents a biological update of American plaice in NAFO Division 4T. An extensive review of the biology and stock structure was given in Powles (1965, 1969).

DESCRIPTION OF THE FISHERY

The American plaice is a common subarctic flounder found along the Atlantic coast of North America from Cape Cod to Labrador (Powles 1965). The southern Gulf of St. Lawrence supports an important plaice fishery, as well as a more economically important cod fishery. Since the distributions of cod and plaice overlap during the summer, both species are caught simultaneously and the plaice fishery is often thought of as a by-catch fishery to the 4T-4Vn cod fishery.

Tagging and meristic studies indicate that Magdalen Shallows plaice are a discrete stock made up of two main groups (Powles 1965). The groups are maintained by the tendency of plaice to return to the same areas each summer. The northern or 'Miscou-Magdalen' group includes fish of Chaleur Bay, Shippegan Gully, and Orphan Bank regions. The southern or 'Cape Breton' group occurs from Georges Bay to St. Paul Island (Powles 1965). For management and therefore assessment purposes, these two plaice groups from the Gulf of St. Lawrence are considered as one stock.

Development of the Magdalen Shallows plaice fishery started with the introduction of the first offshore otter trawler in 1947 (Powles 1965). With the introduction and subsequent expansion of the otter trawler fleet, plaice had risen rapidly to commercial importance by the mid 1950's. This is presently an exclusively Canadian fishery made up of a fleet of trawlers, seiners, gillnetters and longliners.

NOMINAL CATCHES

Catches from plaice in NAFO Division 4T between 1972-1983 have averaged 8,380 t (Table 2). These plaice catches obtained from NAFO data, do not include the Unspecified Flounder category (Clay et al 1984). Landings for plaice have in the past included 90 percent of the unspecified flounder

category. This was the conclusion of an analysis by ICNAF in 1973 to analyse the species composition of the unspecified flounder category. Thus plaice landings were then corrected for 1963 to 1971. Powles (1969) also studied research vessel surveys and indicated that American plaice comprised 90% of the flatfish in the northern Magdalen Shallows and 80% in the southern half of the Gulf.

Up to 33% of the landings were taken by otter trawlers (OTB1 and OTB2) in 1984 while seiners (SDN and SSN) took 39%. This was different from the 1983 catch, when 18% was taken by trawlers and 67% by seiners (Clay et al 1984). In 1984, gillnet landings were reported as 1,903 t, a four-fold increase over the previous year's catch of 485 t (Table 2).

Trawl catches were concentrated during the summer months in 1983, and again in 1984, especially during August and September (Fig. 2). Seine catches were high throughout the season in 1984, until November. Seine catches in 1983 peaked in June and July. An increase in gillnet landings occurred in August and in September of 1984 (Table 3).

The provisional catch for 1984 was 9442 t. This was an increase of 3105 t since 1983.

AGE COMPOSITION

The commercial catch at age for 1983 and 1984 was constructed from 5,884 fish sampled in 1983 and 7,137 fish in 1984. There were 790 otoliths collected for age determinations in 1983 and 987 in 1984.

The age composition for 1983 was derived by combining the samples by major gear category; trawl, line and gillnet, to obtain three keys for sexes combined. These keys were applied to landings to obtain numbers at age.

In 1984, there were no gillnet samples, and landings for gillnets and other miscellaneous gear were applied to longline samples. This may have caused a bias toward older ages, since longliners usually capture older fish.The growth parameters were obtained from research vessel surveys in 1983 for sexes combined and applied to both 1983 and 1984 keys.

The age composition of plaice for 1984 differs from that of 1983 by the predominance of 11 year old fish. In 1983 there were mostly 11-13 year old fish in the landings. There is some evidence of remnants of the 1972, 1973, and 1974 year-classes passing through the fishery.

The catch at age for 1977-1980 was taken from Metuzals (1981). Catch at age before 1977 was obtained from Schweigert (1978).

RESEARCH VESSEL SURVEYS

Stratified random surveys have been carried out in the Gulf of St. Lawrence, NAFO Division 4T since 1971 during September for all groundfish including plaice.

Mean number per tow and mean weight per tow (Table 4) indicate that the 1984 levels are equivalent to 1982 and to the early 1970's. The mean number

per tow during 1976-1980 indicate high population numbers during that time (Fig. 3). There seems to be a decline in numbers since 1979. The mean weight per tow has followed a similar trend.

Results indicated good recruitment in 1976-1979 when 5+ population numbers were smoothed using the computer function MED3R, developed by G. White (pers. comm.) (Tukey 1977) (Fig. 4). Research vessel population estimates by age and by sex were not available for 1983 and 1984. Estimates from untransformed total numbers of male and female plaice since 1971 indicate a stable population, with high population numbers in 1976-1979 for both males (Table 5) and females(Table 6). Stratified mean catch per tow for sexes combined indicated a high abundance during 1976 and 1977 (Table 7), with a decline since then.

TOTAL MORTALITY ESTIMATES

Total mortality (Z) was calculated using ages 4-8 and 5-9 from the research cruise surveys from 1971-1982. Since the values fluctuated from 1.06 to -0.77, this method of calculation was not considered reliable estimates of mortality (Table 6 and 7).

DISCARDING PRACTICES

A problem with analytical assessments of plaice is the discarding of small unmarketable fish. Accepted market sized plaice are 30 + cm. Various discard studies in the early sixties have been undertaken (Table 8), and estimates of as high as 60 percent by weight (80 percent by number) of plaice discarded have been obtained (Jean 1963). Powles (1969) estimated 21 percent by weight (49 percent by number) from Danish seines in 1961. He found fewer discards and larger sizes of plaice taken by Danish seiners. A D.F.O. unpublished study (1977) estimated plaice and cod discards during the late summer of 1976. Discards rates of 41.9 percent by weight (69.3 percent by number) of plaice were obtained.

Clay et al (1984) described a theoretical change in the pattern of discarding at length, by applying selection ogives to research vessel catch length frequencies. They demonstrated that a larger mean size of plaice was being discarded during the past five years. This increase coincided with a change in mesh regulation, from 120 mm to 130 mm.

Preliminary results from a discard study conducted in 1984 were used to calculate percent discarded at length. This percent at length was then applied to a key obtained from the 1984 research vessel to obtain percent discarded at age.

These results indicate the proposed change in length of discarding did indeed occur. Estimates obtained in 1984 for discards by weight were 39.5 percent (56.1 in number). This is a decrease of 2.4 percent by weight (13.2 in number) when compared to the 1976 study.

CATCH AT AGE

Discards at age were available for 1976, 1980 and 1984. These estimates and prorated values for the intervening years (see below) were applied to the commercial landings-at-age table to obtain a representative catch at age for 1984 (Table 9).

Since estimates for 1979 (unpublished data) and 1980 were taken at the same time as a mesh regulation change (to 120 mm), average discards at age were calculated to apply to the years 1979-1981. From 1981 to 1984, discard estimates from the 1984 study were applied. This estimate in 1984 is applicable for these years since a mesh size of 130 mm regulation occurred (Table 10).

Percent catch at age (with discard estimates) and without discard estimates (landings at age) are presented in Tables 11 and 12. Landings have 10-11 year old fish in 1983 and 1984. There is evidence that more older fish are present in the commercial samples. Using the discard estimates for 1984, it seems likely that there were more 7 year olds in the catch than calculated from port sampling alone.

VPA ANALYSIS

Catch at age, including and excluding discard estimates from 1977-1984, was calculated using VPA in order to obtain stock abundance estimates.

Input parameters were the historical partial recruitment vector (PR) (averaged over 1977-1980) and the weights at age for 1984. Historical partial recruitment was selected as representing the most constant pattern, even though a mesh regulation change occurred in 1981.

AGE:	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
PR:	.35	.65	.88	1	1	1	1	1	1	1	1	1	1	1	1	1
WT:	.27	.29	.38	.46	.49	.61	.67	.74	.92	1.03	1.16	1.24	1.35	1.32	1.29	1.67

Natural mortality was assumed to be 0.2 for ages 6-21.

These parameters were applied to both numbers-at-age matrices and different terminal F's were tried from 0.1 - 0.5. The VPA analyses were calibrated using exploitable biomass (ages 9-19) and 6+ biomass versus commercial catch rates. The CPUE chosen was the directed catch in hours for plaice by seines, tonnage class 2. The series of resulting terminal F's were examined using the catch matrix including discards (Table 13) and excluding discards (Table 14). Using the criteria of intercept, residuals and correlation coefficient, linear regressions indicated an F_t of 0.4. All regressions of weighted F versus effort were significant, but these were not used in the calibration of the cohort.

Linear regressions of the estimated VPA biomass (1977-1984) obtained from numbers at age including and excluding discards versus research vessel biomass estimates gave a slightly higher correlation coefficient ($r = .75$) with the landings at age (including discards). These results indicate that including discards in a catch matrix may give a better relation to observed research vessel biomass.

The plots in Fig. 5 were calculated by taking the annual biomass estimates obtained from research vessel surveys from 1971-1983 inclusive, and dividing this into the mean biomass. The same calculation was performed on VPA (6+ biomass estimated from VPA using catch at age including discards). Results in Fig. 5 indicate a good relationship of VPA results (1977-1984) with research vessel biomass (1971-1983) for the years 1977 to 1983. The 1984 research vessel biomass estimate was not available. Both biomass estimates (VPA and research) are similar to the commercial catch rates, calculated from directed trips by seines, tonnage class 2. A decline in stock biomass is observed since 1977.

CONCLUSION

Discard estimates have been incorporated into the catch at age from a 1984 study. VPA analyses were performed to obtain exploitable biomass estimates for 1984. Results indicated that a catch at age including discard estimates at age was better correlated with research vessel biomass estimates than a catch at age without discard estimates.

The level of commercial sampling for this stock is inadequate, and the accuracy of the VPA analysis is doubtful. Discarding is also a major problem, and in recent years (1984) discarding by weight is higher than in 1980 but similar to 1976. Discards in terms of numbers, however, have decreased since 1976.

Abundance indices from research vessel surveys (mean numbers and weight per tow) indicate that this stock, with this change in discarding pattern, is able to support a 10,000 t TAC.

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Table 1. Flatfish landings (t) in NAFO Division 4RST during 1963-1984

YEAR	YELLOW-TAIL	ATLANT HALIBUT	GREEN HALIBUT	WITCH	WINTER FLOUNDER	PLAICE	UNSPEC. FLOUNDER	TOTAL FLATFISH
1963	107	537	0	4250	3165	8470	0	16529
1964	65	615	0	3350	3014	8803	9	15856
1965	53	693	24	3608	4419	11098	5	19900
1966	157	612	365	3712	3136	12720	0	20702
1967	79	459	365	2714	2454	10478	24	16573
1968	12	443	686	3388	551	11911	0	16991
1969	268	506	801	4652	1710	10841	0	18778
1970	59	509	1112	4801	2694	13132	0	22307
1971	40	454	954	3821	2842	11765	0	19876
1972	3	310	681	2001	1911	9724	1373	16003
1973	6	385	756	2224	2384	8007	2426	16188
1974	27	418	1011	3247	1976	11261	999	18939
1975	3	272	1544	2722	2050	10177	3951	20719
1976	37	196	2019	6875	2471	14265	1785	27648
1977	30	150	3961	3039	1358	12665	1995	23198
1978	13	135	6247	4510	1236	12375	1196	25712
1979	69	132	8791	4561	1722	12943	894	29112
1980	46	202	7006	3527	2053	11115	1163	25112
1981	14	95	3176	1912	2013	10210	532	17952
1982	5	90	2269	1282	2317	8074	479	14516
*1983	50	173	1577	1030	1799	8268	792	13689
*1984	96	82	1747	1276	1515	10725	0	15441
TOTAL	1,239	7,468	45,092	72,502	48,790	239,027	17,623	431,741
AVERAGE	56	339	2,050	3,296	2,218	10,865	801	19,625

*Provisional

Table 2. American plaice landings (t) in NAFO Division 4T 1972-1984

YEAR: GEAR:	TRAWL	SEINE	GILLNET	OTHER	TOTAL
1972	5135	2315	286	558	8294
1973	3558	2743	241	363	6905
1974	4131	3661	250	443	8485
1975	3989	3878	217	359	8443
1976	6962	3376	225	630	11193
1977	4634	4004	242	350	9230
1978	4540	3489	379	623	9031
1979	4523	3724	750	999	9996
1980	3887	3472	726	207	8292
1981	2623	3575	1084	552	7834
1982	1459	4124	807	119	6509
*1983	1402	4091	485	359	6337
*1984	3114	3676	1903	749	9442
TOTAL	49,957	46,128	7,595	6,311	109,991
AVERAGE	3,843	3,548	584	486	8,461

*Provisional

Table 3. Nominal Catch (t Round Fresh) of Plaice in NAFO Division 4T for 1984.

MONTH	M	A	M	J	J	A	S	O	N	D	UNK	TOTAL
OTB-1	1	2	94	139	52	105	83	67	20			563
OTB-2		11	202	572	316	532	490	319	82	26	1	2551
SDN		158	479	487	356	408	395	520	482	168		3453
SSN		24	95	29	15		4	45	11			223
GNS	52	3	124	246	298	354	419	399	7	1		1903
Others*			48	114	145	86	79	196	44	4	33	749
TOTAL	53	198	1042	1587	1182	1485	1470	1546	646	199	34	9442

* Others include: Midwater trawl, purse seine, longline, handline and miscellaneous gear.

Table 4. Research vessel estimates of mean number per tow and mean weight (kg) per tow for 4T plaice 1971 - 1984.

	MEAN NUMBER/TOW	MEAN WT/TOW
1971	151.53	29.03
1972	127.98	30.53
1973	131.80	37.39
1974	313.32	57.62
1975	294.98	59.48
1976	523.38	95.00
1977	601.90	85.53
1978	321.02	62.39
1979	492.14	92.65
1980	304.11	55.67
1981	352.16	57.02
1982	164.09	35.06
1983	210.66	39.11
1984	157.20	33.40

Table 5. Estimated population numbers ($x10^{-3}$) from E.E. Prince surveys 1971 - 1982.* (Strata 15-39)
- 4T Plaice Males -

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	407	73	315	1	1	0	196	1	1	144	1595	360
2	5287	2260	2228	3362	1876	180	1423	616	342	3556	5772	9711
3	15475	7820	13927	29591	15731	18948	41255	8093	4330	22725	23410	11565
4	25140	19840	19443	95789	52589	100472	158790	76178	39003	55058	54383	10184
5	24424	25336	24679	60926	95898	154511	209225	93376	108318	64801	73123	20282
6	28165	28117	18891	59688	58555	127306	119644	98208	114494	78816	100007	21368
7	26839	27515	15383	36806	50375	53303	63379	96005	134283	44561	88047	34093
8	16140	15176	19245	34069	26884	29066	32142	40941	90905	32912	42445	38078
9	5122	5513	11725	26189	25604	29590	14071	13902	31242	11483	19669	14329
10	3819	5732	5541	4840	11932	21747	8333	8435	19712	5779	11056	4943
11	3247	2212	2919	1502	8399	8254	4450	4449	9959	2774	5064	2414
12	1461	1827	2354	1502	1375	3974	2764	1373	4668	1044	1711	212
13+	2996	731	3604	9729	3134	2783	1302	1047	3916	759	1096	199
UK	253	0	456	9954	140	248	387	3	72	1	919	1829
TOTAL	158,775	142,152	140,710	373,948	352,493	550,382	657,361	442,627	561,245	324,413	428,297	169,567
5+	112466	112159	104797	245205	282296	430782	455697	357739	517569	242930	343137	137747
6+	88042	86823	80118	184279	186398	276271	246472	264363	409251	178129	270014	117465
7+	59877	58706	61227	124591	127843	148965	126828	166155	294757	99313	170007	96097
z(5-6)	.26	.34	-.56	.27	.02	.56	.54	-.13	1.06	-.11	1.07	

* Data unavailable for 1983 and 1984.

Table 6. Estimated population numbers ($x10^3$) from E.E. Prince surveys 1971 - 1982.* (Strata 15-39)
- 4T Plaice Females -

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0	345	1	1	74	0	1	1	1	578	284	82
2	4082	3925	4600	1	1779	759	2551	1	324	3339	5400	4172
3	13777	8526	12185	35224	10118	19922	39022	784	3321	16002	10557	5407
4	23338	17065	16307	48929	42696	76401	96170	12643	33729	32916	24969	8189
5	22159	11880	16808	44138	74784	121015	139808	21880	87124	37626	33746	16385
6	20508	13474	13412	44989	31410	91803	85568	26820	68537	48621	34875	13005
7	24737	19675	11720	16498	22805	48846	71319	28870	78316	46747	54924	17885
8	16176	17913	13297	17065	18543	22660	30412	36302	68817	39658	40324	32768
9	5097	9423	13863	19230	10949	18797	11681	12518	41695	26390	35087	22514
10	3173	2795	5969	19221	11056	10677	7743	9691	18564	13537	17343	19930
11	3179	1612	2668	2909	9151	14312	5338	4278	10781	8597	8444	7540
12	2870	2189	1798	1949	3098	9251	3922	3183	6461	5198	4730	4437
13+	7192	4345	12590	5288	7290	14748	8009	7906	16828	8532	9430	9785
UK	17	44	118	1969	3	1050	2	4	222	0	33	109
TOTAL	146305	113211	125336	257411	243756	450241	501546	164881	434720	287741	280146	162208
5+	105108	83350	92243	173256	189089	353159	363802	151452	397345	234906	238936	144358
6+	82949	71470	75435	129118	114305	232144	223994	129572	310221	197280	205190	127973
7+	62441	57996	62023	84129	82895	140341	138426	102752	241684	148659	170315	114968
z(5-6)	.39	.10	-.34	.42	-.21	.46	1.03	-.72	.70	.14	.62	

* Data unavailable for 1983 and 1984.

Table 7. Stratified mean catch per standard tow (in numbers weighted by Stratum) of plaice during E.E. Prince cruise (Strata 15-39) for 1971-1982.*

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.19	0.22	0.14	0.07	0.03	0.00	0.05	0.00	0.00	1.10	1.31	0.00
2	3.82	2.84	2.90	5.51	1.20	0.34	1.41	0.18	0.37	3.77	6.13	4.65
3	11.67	7.37	13.22	20.12	9.25	14.09	30.04	2.75	3.45	16.77	13.35	9.96
4	19.10	15.64	18.15	42.92	37.32	74.80	99.42	28.90	29.04	34.19	27.54	13.00
5	19.83	14.01	19.75	34.96	70.14	141.61	157.33	39.53	76.97	41.63	40.56	37.17
6	21.42	14.31	15.10	26.73	33.97	115.89	107.46	44.29	74.35	53.75	49.03	42.34
7	22.38	15.93	12.50	16.86	25.87	54.68	78.99	45.54	89.16	40.03	56.49	81.30
8	13.80	10.91	14.71	12.73	15.98	24.39	35.15	29.19	68.65	31.09	33.10	67.36
9	4.11	4.92	11.75	14.81	12.38	22.04	13.14	11.21	31.62	15.89	23.12	50.49
10	2.70	2.96	5.32	7.88	8.10	14.82	7.77	8.01	16.52	7.70	11.97	22.71
11	2.41	1.44	2.56	3.65	6.31	10.90	4.73	4.61	9.24	4.78	4.75	5.44
12	1.59	1.57	1.86	1.51	1.92	6.92	3.10	2.64	5.20	2.74	2.29	.70
13	0.99	.74	1.36	1.15	1.11	4.47	1.90	2.98	3.33	2.20	1.25	0.00
14	0.88	0.59	1.59	1.78	1.14	2.16	1.09	1.36	3.12	1.10	.91	0.00
15	0.46	0.32	0.71	0.96	0.83	1.18	1.60	0.87	1.91	0.60	.73	.57
16+	1.24	0.51	2.40	1.40	3.08	2.41	0.92	1.59	2.55	0.88	1.40	.96
TOTAL	126.59	94.28	124.02	193.04	228.63	490.70	544.10	223.65	415.48	258.22	273.93	336.65
(4 - 8)	96.53	70.80	80.21	134.20	183.28	411.37	478.35	187.45	388.17	200.69	206.72	241.17
(5 - 9)	81.54	60.08	73.81	106.09	158.34	358.61	392.07	169.76	340.75	182.39	202.30	278.66
z		.47	.04	-.28	.17	-.67	.05	1.04	-0.60	.62	-.01	-0.80

*Mean catch per tow at age unavailable for 1983 and 1984.

Table 8. Percent Discards.

	NOS.	WT.	REF.
1984	56.1	39.5	Chouinard and Metuzals 1984
1980	50.9	25.1	Cliche (1981)
1979	52.5	31.7	Metuzals unpubl. data.
1976	69.3	41.9	D.F.O. Unpublished Study[1]
1961	49.0	21.0	Powles (1969)
1959	81.0	60.0	Jean (1963)
1958	74.0	34.0	Jean (1963)
1957	70.0	40.0	Jean (1963)

[1]D.F.O. Unpublished Study (1977) for 4T-NKL from August - October, 1976.

Table 9. Percent at age discarded for plaice in 4T.

	1976[1]	1979[2]	1980[3]	1984[4]
3	100	100	100	100
4	100	81	100	96
5	96	96	100	96
6	88	87	97	92
7	75	81	86	88
8	47	62	68	81
9	20	38	50	66
10	10	20	25	46
11	4	10	13	0
12	2	8	0	0
13	1	3	0	0
14	0	2	0	0
15	0	1	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0
MESH:	114 mm	120 mm		130 mm

[1]D.F.O. Unpublished Study 1977 estimates in Schweigert 1978.

[2]Metuzals unpubl. data.

[3]Cliche, 1981.

[4]Chouinard and Metuzals, 1985.

Table 10. Catch at age ($X10^{-3}$) for 4T Plaice including discards.

	1964	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
6	6220	8243	9350	7422	7595	6502	2012	2189	1975	1813	2004	2205	5557	7027	5903	4463	638	558	358	400	4015
7	7011	9291	10539	8366	8560	7329	4371	4758	4291	3940	4355	4792	6716	10036	7171	6188	2838	1380	330	2080	6310
8	4431	5873	6661	5288	5411	4633	3425	3726	3362	3087	3412	3755	4784	5006	5472	10683	2680	2825	1963	1975	4469
9	2798	3708	4207	3339	3417	2925	2994	3259	2939	2699	2983	3282	2750	2797	2638	12270	3258	3660	3528	2034	3972
10	2339	3099	3516	2791	2856	2445	3952	4302	3880	3563	3938	4333	2713	2213	2318	4017	2229	4503	3980	1566	4506
11	1645	2179	2472	1962	2008	1719	2629	2862	2581	2370	2620	2882	2118	1588	1793	2121	1871	1756	2343	2125	3897
12	1793	2376	2695	2140	2189	1874	1509	1642	1481	1360	1503	1654	2636	1782	1179	1222	2095	1441	2359	1399	2563
13	957	1268	1438	1142	1168	1000	976	1062	956	880	972	1070	1404	870	1105	1052	1311	813	1212	1330	973
14	529	701	795	631	646	553	750	816	736	676	747	822	781	435	540	709	1128	671	882	756	1294
15	305	404	458	364	372	319	619	674	608	558	617	678	420	210	407	250	762	975	410	531	1085
16	304	403	457	363	371	316	480	522	471	433	478	526	431	117	113	155	416	533	386	526	533
17	165	219	248	197	202	173	726	790	713	655	723	796	374	73	77	104	267	697	272	495	453
18	115	153	173	137	141	120	57	63	56	52	57	63	233	101	83	31	90	405	236	327	441
19	114	151	171	136	139	119	7	8	7	7	7	8	274	53	44	63	67	127	19	349	208
20	90	120	136	108	110	94	6	6	5	5	6	6	187	62	27	77	32	146	21	164	119
21	42	55	63	50	51	44	12	13	12	11	12	13	111	11	179	109	29	140	144	91	73

Catch at age ($X\ 10^{-3}$) for 4T plaice excluding discards.

6	715	947	1075	853	873	747	231	252	227	208	230	253	639	808	679	357	51	39	25	28	281
7	1753	2323	2635	2092	2140	1832	1093	1190	1073	985	1089	1198	1679	2509	1793	990	454	138	33	208	631
8	2332	3091	3506	2783	2848	2438	1803	1962	1769	1625	1796	1976	2518	2632	2880	3739	938	452	314	316	715
9	2238	2966	3366	2671	2734	2340	2395	2607	2351	2159	2386	2626	2200	2238	2110	6871	1824	915	882	511	993
10	2126	2817	3196	2537	2596	2223	3593	3911	3527	3239	3580	3939	2466	2012	2107	3093	1716	1576	1393	548	1612
11	1582	2095	2377	1887	1931	1653	2528	2752	2482	2279	2519	2771	2037	1527	1724	1866	1646	948	1265	1147	2104
12	1758	2329	2642	2098	2146	1837	1479	1610	1452	1333	1474	1622	2584	1747	1156	1124	1927	893	1462	867	1589
13	952	1262	1431	1136	1162	995	971	1057	953	876	967	1065	1397	866	1100	1020	1271	642	957	1050	788
14	529	701	795	631	646	553	750	816	736	676	747	822	781	435	540	694	1105	637	837	718	1229
15	305	404	458	364	372	319	619	674	608	558	617	678	420	210	407	250	762	975	410	531	1085
16	304	403	457	363	371	318	480	522	471	433	478	526	431	117	113	155	416	533	386	526	533
17	165	219	248	197	202	173	726	790	713	655	723	796	374	73	77	104	267	697	272	495	453
18	115	153	173	137	141	120	57	63	56	52	57	63	233	101	83	31	90	405	236	327	441
19	114	151	171	136	139	119	7	8	7	7	7	8	274	53	44	63	67	127	19	349	208
20	90	120	136	108	110	94	6	6	5	5	6	6	187	62	27	77	32	146	21	164	119
21	42	55	63	50	51	44	12	13	12	11	12	13	111	11	179	109	29	140	144	91	73

Table 11. Percent Catch at age for 4T plaice including discards.

	1964	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
6	21.6	21.6	21.6	21.6	21.6	21.6	8.2	8.2	8.2	8.2	8.2	8.2	17.6	21.7	20.3	10.3	3.2	2.7	1.9	2.5	11.5
7	24.3	24.3	24.3	24.3	24.3	24.3	17.8	17.8	17.8	17.8	17.8	17.8	21.3	31.0	24.7	14.2	14.4	6.7	1.8	12.9	16.0
8	15.4	15.4	15.4	15.4	15.4	15.4	14.0	14.0	14.0	14.0	14.0	14.0	15.2	15.4	18.8	24.6	13.6	13.7	10.6	12.2	12.8
9	9.7	9.7	9.7	9.7	9.7	9.7	12.2	12.2	12.2	12.2	12.2	12.2	8.7	8.6	9.1	28.2	16.5	17.7	19.1	12.7	11.3
10	8.1	8.1	8.1	8.1	8.1	8.1	16.1	16.1	16.1	16.1	16.1	16.1	8.6	6.8	8.0	9.2	11.3	21.8	21.6	9.7	13.1
11	5.7	5.7	5.7	5.7	5.7	5.7	10.7	10.7	10.7	10.7	10.7	10.7	6.7	4.9	6.2	4.9	9.5	8.5	12.7	13.2	11.1
12	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	8.4	5.5	4.1	2.8	10.6	7.0	12.8	8.7	7.3
13	3.3	3.3	3.3	3.3	3.3	3.3	4.0	4.0	4.0	4.0	4.0	4.0	4.5	2.7	3.8	2.4	6.7	3.9	6.6	8.2	2.8
14	1.8	1.8	1.8	1.8	1.8	1.8	3.1	3.1	3.1	3.1	3.1	3.1	2.5	1.3	1.9	1.6	5.7	3.3	4.8	4.7	3.7
15	1.1	1.1	1.1	1.1	1.1	1.1	2.5	2.5	2.5	2.5	2.5	2.5	1.3	0.6	1.4	0.6	3.9	4.7	2.2	3.3	3.1
16	1.1	1.1	1.1	1.1	1.1	1.0	2.0	2.0	2.0	2.0	2.0	2.0	1.4	0.4	0.4	0.4	2.1	2.6	2.1	3.3	1.5
17	0.6	0.6	0.6	0.6	0.6	0.6	3.0	3.0	3.0	3.0	3.0	3.0	1.2	0.2	0.3	0.2	1.4	3.4	1.5	3.1	1.3
18	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.7	0.3	0.3	0.1	0.5	2.0	1.3	2.0	1.3
19	0.4	0.4	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.2	0.2	0.1	0.3	0.6	0.1	2.2	0.6
20	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.1	0.2	0.2	0.7	0.1	1.0	0.3
21	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.6	0.3	0.1	0.7	0.8	0.6	0.2

Table 12. Percent catch at age for 4T plaice excluding discards.

	1964	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
6	4.7	4.7	4.7	4.7	4.7	4.7	1.4	1.4	1.4	1.4	1.4	1.4	3.5	5.2	4.5	1.7	0.4	0.4	0.3	0.4	2.2
7	11.6	11.6	11.6	11.6	11.6	11.6	6.5	6.5	6.5	6.5	6.5	6.5	9.2	16.3	11.9	4.8	3.6	1.5	0.4	2.6	4.9
8	15.4	15.4	15.4	15.4	15.4	15.4	10.8	10.8	10.8	10.8	10.8	10.8	13.7	17.1	19.2	18.2	7.4	4.9	3.6	4.0	5.6
9	14.8	14.8	14.8	14.8	14.8	14.8	14.3	14.3	14.3	14.3	14.3	14.3	12.0	14.5	14.0	33.4	14.5	9.9	10.2	6.5	7.7
10	14.1	14.1	14.1	14.1	14.1	14.1	21.5	21.5	21.5	21.4	21.5	21.5	13.5	13.1	14.0	15.1	13.6	17.0	16.1	7.0	12.5
11	10.5	10.5	10.5	10.5	10.5	10.5	15.1	15.1	15.1	15.1	15.1	15.1	11.1	9.9	11.5	9.1	13.1	10.2	14.6	14.6	16.4
12	11.6	11.6	11.6	11.6	11.6	11.6	8.8	8.8	8.8	8.8	8.8	8.8	14.1	11.3	7.7	5.5	15.3	9.6	16.9	11.0	12.4
13	6.3	6.3	6.3	6.3	6.3	6.3	5.8	5.8	5.8	5.8	5.8	5.8	7.6	5.6	7.3	5.0	10.1	6.9	11.1	13.3	6.1
14	3.5	3.5	3.5	3.5	3.5	3.5	4.5	4.5	4.5	4.5	4.5	4.5	4.3	2.8	3.6	3.4	8.8	6.9	9.7	9.1	9.6
15	2.0	2.0	2.0	2.0	2.0	2.0	3.7	3.7	3.7	3.7	3.7	3.7	2.3	1.4	2.7	1.2	6.1	10.5	4.7	6.7	8.4
16	2.0	2.0	2.0	2.0	2.0	2.0	2.9	2.9	2.9	2.9	2.9	2.9	2.4	0.8	0.8	0.8	3.3	5.8	4.5	6.7	4.1
17	1.1	1.1	1.1	1.1	1.1	1.1	4.3	4.3	4.3	4.3	4.3	4.3	2.0	0.5	0.5	0.5	2.1	7.5	3.1	6.3	3.5
18	0.8	0.8	0.8	0.8	0.8	0.8	0.3	0.3	0.3	0.3	0.3	0.3	1.3	0.7	0.6	0.2	0.7	4.4	2.7	4.2	3.4
19	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.3	0.3	0.3	0.5	1.4	0.2	4.4	1.6
20	0.6	0.6	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.4	0.2	0.4	0.3	1.6	0.2	2.1	0.9
21	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.1	1.2	0.5	0.2	1.5	1.7	1.2	0.6

Table 13. Biomass estimates ($\times 10^{-3}$) including discards.

		correlation	intercept	predicted	observed
F_T=.1	6+/CPUE	-0.514	152.90	136.8	135.5
	F/E	0.436			
	Exp bio/CPUE	-0.096	159.05	151.4	181.6
F_T=.2	6+/CPUE	0.886	60.00	68.52	67.75
	F/E	0.657			
	Exp bio/CPUE	0.344	51.39	74.00	90.81
F_T=.3	6+/CPUE	0.922	29.11	45.78	45.17
	F/E	0.753			
	Exp bio/CPUE	0.490	15.68	48.22	60.54
F_T=.4	6+/CPUE	0.891	13.63	34.42	33.88
	F/E	0.798			
	Exp bio/CPUE	0.554	-2.12	35.32	45.41
F_T=.5	6+/CPUE	0.875	4.3	27.61	27.10
	F/E	0.823			
	Exp bio/CPUE	0.590	-12.88	27.53	36.32

Table 14. Biomass estimates ($\times 10^{-3}$) excluding discards.

		correlation	intercept	predicted	observed
$F_T = .1$	6^+/CPUE	.947	64.02	88.08	87.51
	F/E	.790			
	Exp bio/CPUE	.478	51.46	77.94	92.82
$F_T = .2$	6^+/CPUE	.876	16.42	43.62	43.76
	F/E	.865			
	Exp bio/CPUE	.611	6.9	37.81	46.41
$F_T = .3$	6^+/CPUE	.841	538.46	28.80	29.17
	F/E	.874			
	Exp bio/CPUE	.648	-7.84	24.44	30.94
$F_T = .4$	6^+/CPUE	.824	-7.4	21.40	21.88
	F/E	.876			
	Exp bio/CPUE	.664	-15.18	17.75	23.20
$F_T = .5$	6^+/CPUE	.814	-12.19	16.97	17.50
	F/E	.878			
	Exp bio/CPUE	.673	-19.58	13.74	18.56

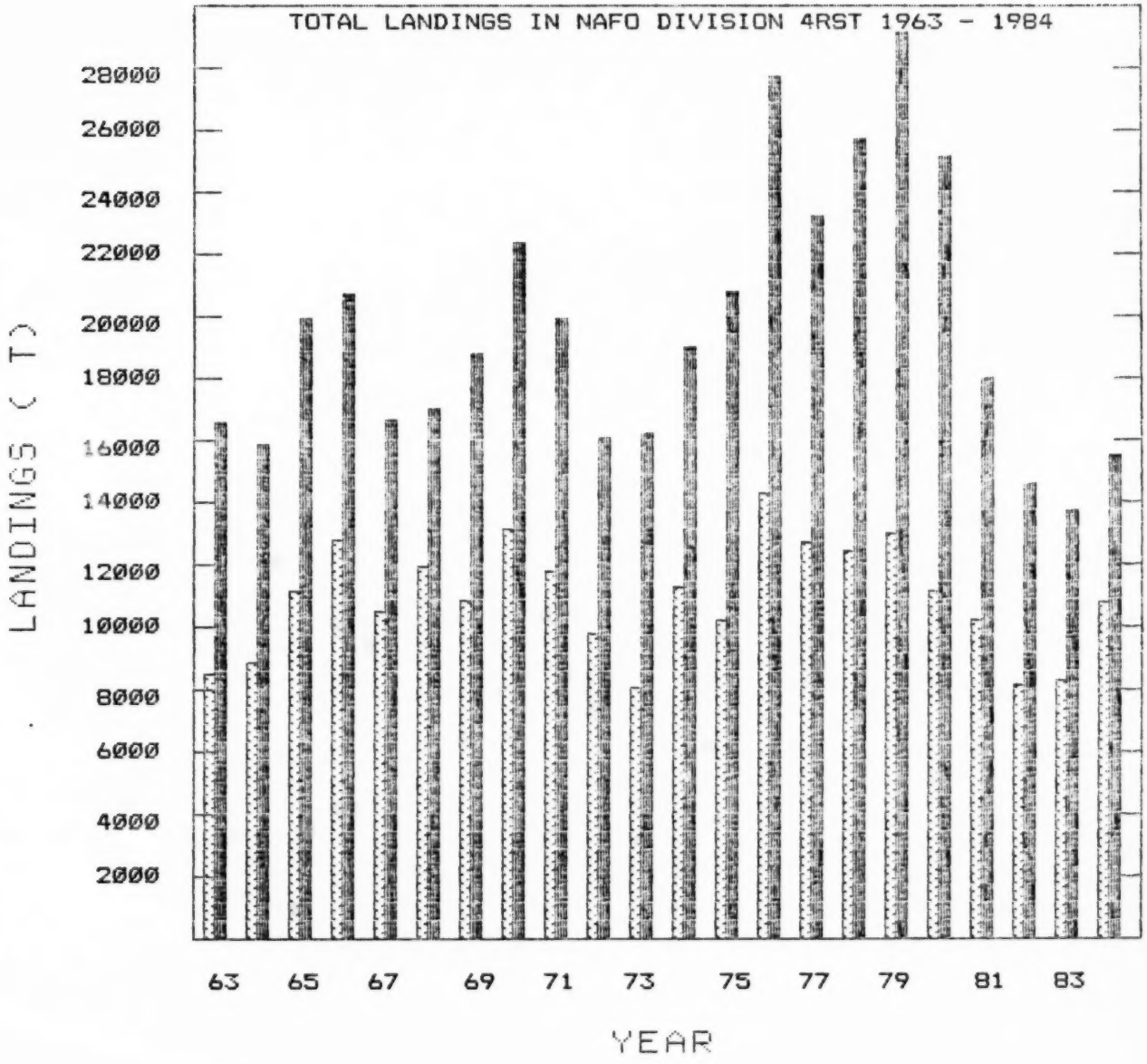

Fig. 1. Total flatfish landings for NAFO Division 4RST.

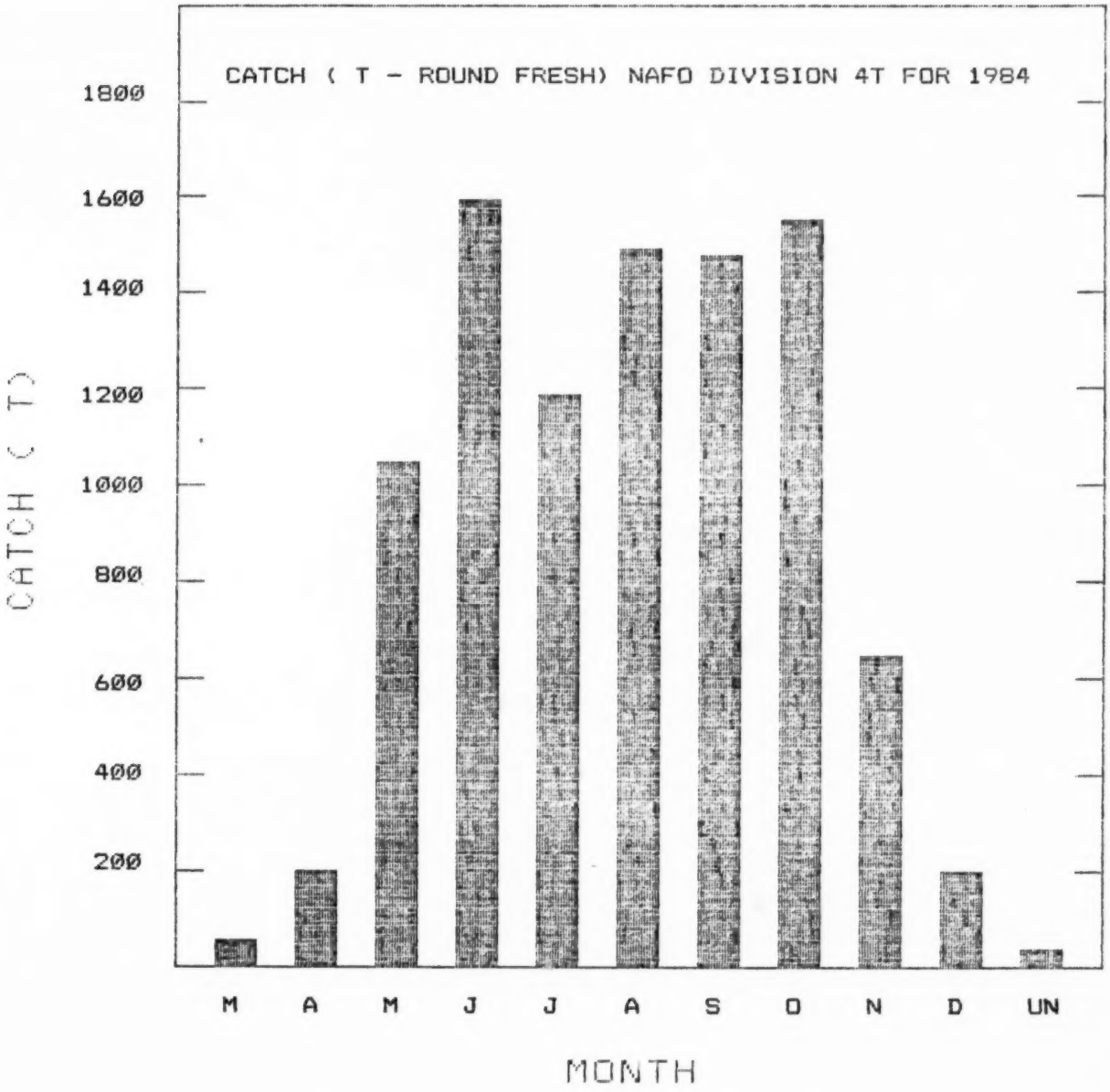

Fig. 2. Landings by month for 4T plaice in 1984.

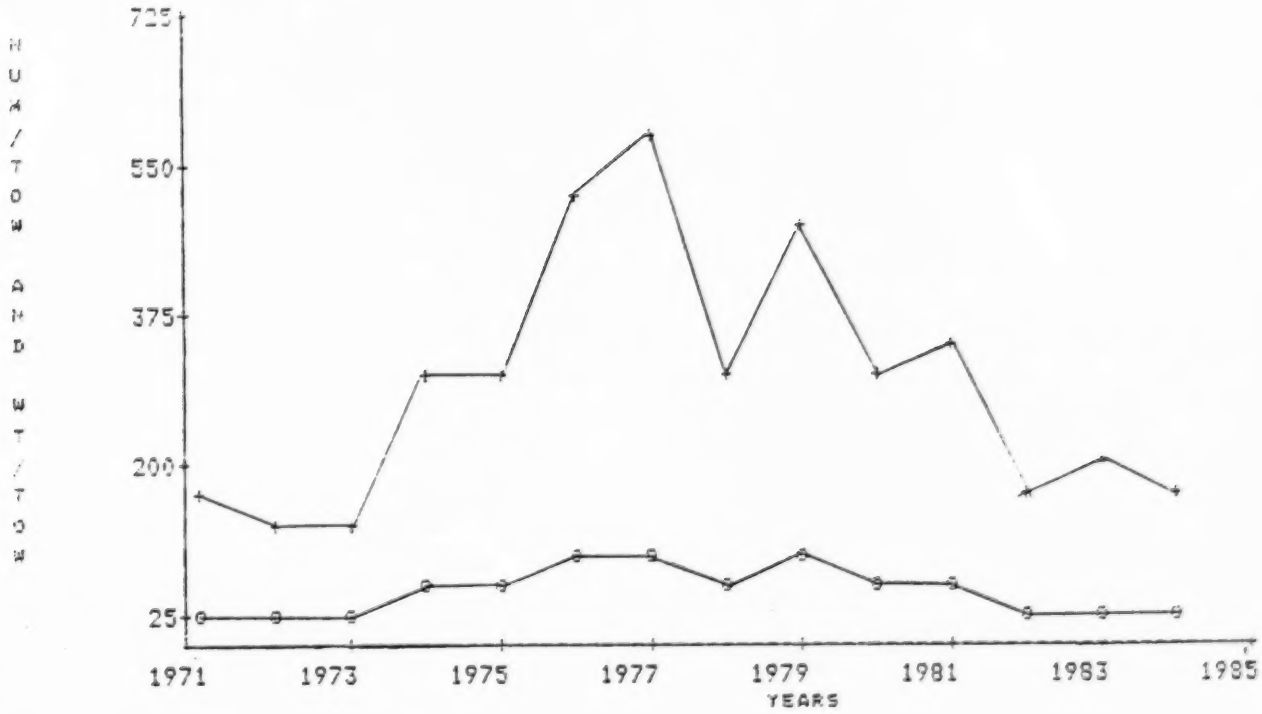

Figure 3. Research vessel abundance indices, number per standard tow (+) and weight per tow (0) from 1971-1984.

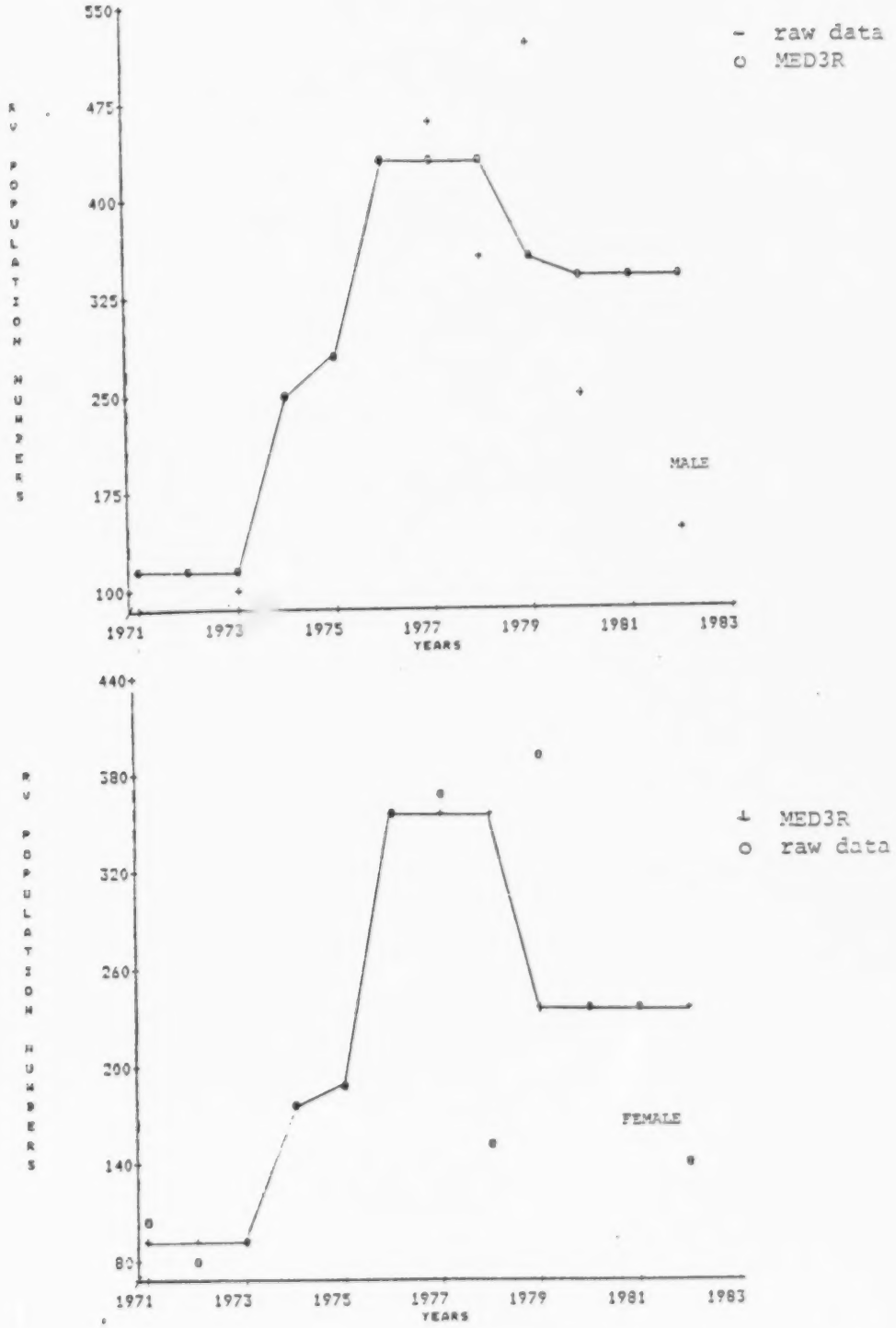

Figure 4. Research vessel population estimates 1971-1982 in numbers $X10^{-3}$ of 5+ male (top) and 5+ female plaice (bottom) using median smoothing function.

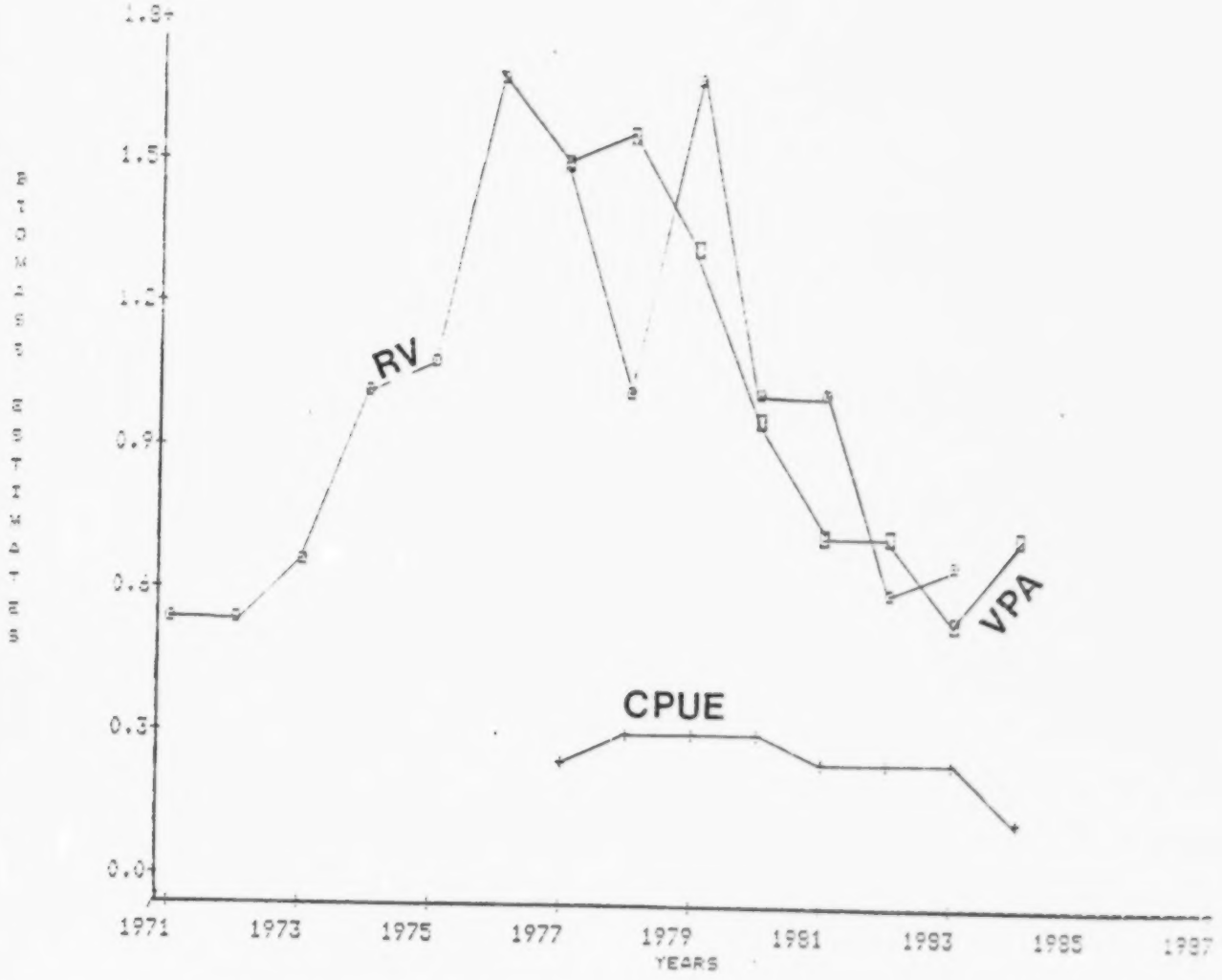

Fig. 5. Mean biomass estimates from research vessel surveys (RV) and (VPA). CPUE is derived from directed trips for plaice from Danish seines.